

manufacturing center, on the following day, gave 2,036 particles per cubic centimeter.

On September 24 and 25, at about 10 a. m., and on October 11 at 4 p. m., dust records obtained at the Federal Building, in the loop district, Chicago, Ill., gave 6,070, 7,180, and 4,530 particles per cubic centimeter, respectively. Records obtained at Chicago University, in a residence section of the city, at about 8 a. m. on September 24, 25, 26, and at 10 a. m. on October 10, gave 4,800, 3,830, 3,110, and 1,920 particles per cubic centimeter, respectively. On none of these days was the smoke particularly dense for Chicago. Nevertheless the two morning measurements at the Federal Building show a greater number of particles than has ever been found in Washington.

Acknowledgments.—We take this opportunity of expressing our grateful appreciation of the hearty cooperation extended to us, in the execution of the investigations at high altitudes, by Lieut. B. J. Sherry, Meteorological Office, Lieut. L. J. Maitland, operations officer, Lieut. St. Clair Streett, model control officer, and the various other officers from Bolling Field who piloted planes from which observations were made. Without such cooperation, given in a spirit that indicated an appreciation of

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NOTE ON ORGANIC BODIES FOUND IN THE AIR OF WASHINGTON AND LONDON

By SIR NAPIER SHAW, F. R. S., Chairman of the Advisory Committee on Atmospheric Pollution, London

It was reported on August 25 last by Dr. H. H. Kimball of the Weather Bureau, United States Department of Agriculture, that during the whole of August unusual and comparatively large opalescent particles had been encountered in samples of dust taken in Washington by means of the jet instrument supplied to him through the International Union of Geophysics and Geodesy. These particles had not yet been identified. They were present in large numbers in records taken both on the ground and from an airplane.

At the beginning of September a specimen slide containing some of the particles was received in London from Doctor Kimball. The particles had the appearance of definitely organic structures, some unicellular and some bicellular; they were usually clear, turgid and spherical or oval but sometimes irregular, with as many as nine short but well-defined protuberances. No nuclei could be seen in the cells.

Drawings of the best defined particles were made and these were exhibited by Doctor Owens at the soirée of the British Association in Liverpool.

Somewhat similar particles evidently of organic origin, considered to be pollen grains or spores, had been obtained occasionally by Doctor Owens in records taken in this country at a rural station. The numbers were, however, always very small and no such particles had ever been noticed in records of suspended matter in London.

On October 10, 1923, a record of 1,000 c. c. taken at South Kensington in the usual way was found to contain two large bodies identical in appearance with some of the opalescent particles in the American record. These were single oval cells filled with finely granular matter, each 6 microns long by 3.75 microns wide, with a well-defined papilla at one extremity. The cell wall appeared rough and pitted, and was appreciably thinner at the top of the papilla than at other points. Since this date particles of definite structure have been found in a large number of records.

On October 11 at South Kensington, the bodies were present to the extent of about two per liter. A record

the problems to be solved, the work could not have been accomplished.

SUMMARY

Surface visibility is a poor criterion of visibility at the ordinary levels of air navigation. After leaving the ground on a morning when objects could be seen at a distance of 20 miles or more, upon reaching a height of 3,000 feet it appeared as though the plane were flying in dense smoke and the visibility decreased to 10 miles.

On the other hand, on October 30, with light fog and poor seeing at the surface, at 10,000 feet the visibility was 100 miles.

The visibility from the air is greatly diminished by clouds even in the incipient form.

The dust content of the air in the city of Washington was markedly increased during the winter of 1922-23 by the enforced use of bituminous coal in heating private dwellings.

While mineral matter, loess, spores, diatoms, and pollen have been identified in atmospheric dust, and also transparent spherical particles of a glassy nature, probably from local furnaces, no dust that appeared to be of volcanic or cosmical origin has been observed.

taken at 10:15 a. m. contained a perfectly clear spherical body 5 microns in diameter with smooth surface, a similar body with rough and crinkled wall, and a cigar-shaped structure divided in the middle and containing two definite oval cells. The latter was not turgid but bent over in the middle.

When water was introduced under the cover slip, the cigar-shaped particle immediately became turgid and apparently split open near one end. The length of the extended particle was 10.8 microns. The center partition dividing the body into two equal cells was well defined.

A small quantity of a solution of gentian violet was introduced under the cover slip. The cigar-shaped particle and the sphere with the rough wall at once took up the stain and became almost black, but the clear sphere was unaffected.

Further records were found to contain similar oval and spindle-shaped particles, which readily took up the stain when mounted in blue glycerin jelly.

A number of records have since been taken at different hours, from which it is concluded that the organic particles have not been present at all times of the day in London. For instance, records taken in Bloomsbury on Sunday, October 14, at 1 a. m. and at 12:15 p. m. contained no definite organic structures, but many square and hexagonal crystals, some of which were quite well formed.

Again, at 8:30 a. m. on October 17, records were taken simultaneously at Cheam, near London (fig. 1, Pl. II) and at London, in Bloomsbury. The record at Cheam contained at least 20 definitely organic particles per liter, generally oval in shape and up to 12 microns in length, together with approximately 630 smoke particles per c. c. whereas the London record contained only 5 or 6 such bodies, and all less than 5 microns in length. The number of smoke particles shown by the London record was approximately 5,000 c. c. The organic particles from the air of Cheam on this occasion were of particular interest. Three roughly oval cells, each about 4 microns

long by $2\frac{1}{2}$ microns wide were found actually connected together end to end and the two end cells showed signs of further subdivision by a pronounced thickening of the walls about the middle. (Fig. 1, Pl. II.) Another body took the form of a single oval cell 10 microns long by 5.7 microns wide, full of clear colorless matter. (Fig. 2, Pl. II.) The cell wall was smooth and at one extremity there was a very well-defined papilla, giving the whole a shape rather like a lemon. Another somewhat cylindrical cell 12 microns long by 3.3 microns wide bore side markings suggesting points of attachment to other cells, which gave it an appearance resembling a portion of a cabbage stalk stripped of the leaves.

Yet another cell, roughly square with a side of 5.8 microns, contained a reddish-brown ball of 4 microns diameter with rough surface—possibly a zygospore.

Photographs of particles obtained on other occasions are given in Figures 3 to 8, Plates II and III.

The volume of air passed through the instrument in taking the above records was in each case 500 c. c.

A further record taken on the same day in Westminster shortly after 4 p. m. contained a clear oval body 6.7 microns long by 3.3 microns wide, on which appeared six small budlike protuberances, irregularly spaced on the surface. At 4:30 p. m. five of these appeared equal in size, the sixth being much smaller; 15 minutes later two of the processes had practically disappeared, while two of the remaining had appreciably increased in size. At 4:50 p. m. four processes remained, one of which had still further increased. Forty minutes later the smallest protuberance which had hitherto remained unchanged was found to have disappeared and its former position was marked by a small black particle not more than half a micron in diameter, just appreciably separated from the main body, suggesting at first sight that the process had not become completely severed. It is, however, more probable that the black spot was a smoke particle at first unnoticed owing to its being hidden by the process which had now been withdrawn into the main cell. Of the three remaining, the largest process had further appreciably increased since 5 p. m. and took the form, roughly, of a hemisphere of radius somewhat less than 1 micron.

On the morning of October 18, the oval body remained as a single cell with no protuberances, unaltered in size within the limits of accuracy of measurement.

This cell appeared to be not quite turgid and the former positions of two of the processes were marked by the light irregularities in its outline. Beyond this no traces remained, but the single smoke particle near the body, already referred to, was visible. It is thus probable that the rapid changes first noted in the appearance of the body may have been due to loss of water by evaporation owing to the focussing upon it of heat rays by the illumination of the microscope.

The slide was gently warmed by placing it under the microscope lamp for four hours, but no resulting change in appearance of the body was detectable.

ORIGIN OF ORGANIC PARTICLES

The occurrence of particles unlike anything previously noted, either in America or England, appears to suggest a common origin, and the fact that they occurred in greatest numbers during exceptionally wet and windy weather precludes the possibility of their being dust particles raised from the ground. Again the difference in the number of particles present in London and at Cheam, in Surrey, at the same time points to some local source.

The most probable explanation appears to be that they are spores of some fungus, the growth of which has been favored by the wet weather. A portion of a whitish mold—probably mucor or crystopus—found on a fallen apple at Cheam was examined and found to contain a large number of readily stainable globular cells, similar in size to those obtained in the records.

In size and all other respects, the organic bodies correspond with spores of almost any mildew, rust or smut, which, according to one textbook "flourish in proportion to the wetness of the season or the dampness of the locality." Spores of corn smut and grass smut, and indeed of most of the Ustilaginaceæ correspond closely with the particles found, as do also the conidia of white rust.

Many of the spores of the Ustilaginaceæ are colored, and may possibly account for some of the isolated colored, spherical particles which have been occasionally found in previous records, although it is known that colored glassy spheres are also produced in furnaces.

Conidia of white rust (*Cystopus candidus*) are normally of about 13 or 14 microns in diameter. In the presence of moisture these swell and at one extremity of each there is produced an obtuse papilla. Vacuoles are formed in the contents of each conidium and the protoplasm becomes separated by fine lines of demarcation into five to eight portions, which develop into zoospores in the course of from one and one-half to three hours. If not immersed in water, the conidia of *Cystopus* may remain unchanged for as long as a month.

Thus every kind of definitely organic particle encountered may be explained on the basis of spores of micro-fungi, and the recent abnormal increase in their number may be the outcome of weather conditions particularly favorable to their development.

It is probably more than a coincidence that these mold cells appeared in the autumn apparently for the first time, or at least were detected then for the first time, and one naturally looks for something which occurred in the autumn and not at other times of the year to account for this. The fall of the leaf is one of the most obvious signs of autumn and when the leaves are dead and exposed to continuous damp they are likely to grow molds of different kinds.

One can easily conceive of threads of mold cells growing up from the surface of dead leaves and the terminal cells of spores produced, being swept away by the wind. Also when the leaves have fallen they are carried about in the wind and rubbed against each other, so that any mold on the surface is more than likely to become detached and set free in the air.

To test this hypothesis Doctor Owens selected a number of dead leaves from the trees in the neighborhood of Cheam and on examining these under the microscope there was evidence in some of them of mold but not in any quantity. The leaves were dry at the time and possibly it would have become detached but in the angle between the midrib and the lateral ribs of the leaves at the back there were in many cases masses of white threadlike material. A piece of one of these leaves was placed on a drop of water under a watch glass and within 12 hours a plentiful crop of mold had appeared with branched threads of spores.

The possibility of fungi growing on the blotting paper lining the walls of the dampening chamber of the instrument has not been overlooked. Records were taken for comparison using a damping chamber freshly prepared with new blotting paper. The result in each case was the same and no growth whatever could be detected on

the old blotting paper after removal from the instrument.

It appears probable, therefore, that dead leaves were the chief source of the mold cells found in the air.

As a further test, on October 29, a disk was cut from a leaf of suitable dimensions to fit in the jet dust counter; this was sterilized by boiling; a record was taken on it by drawing 1,000 c.c. of air through at 9 a. m. and the disk of leaf placed under a glass in a drop of boiled water in a dark place.

A similar test was made on October 30 but the result of the experiment was negative. This, of course, may be due to the absence of spores in the air when the records were taken, and as a matter of fact records taken at the same time and examined microscopically did not show any spores present. It appears, however, fairly certain that the origin of the mold cells is as indicated, that is, from the dying leaves in the autumn, the conditions being very suitable.

THE DUST FALL OF MARCH 29, 1924: A PRELIMINARY NOTE

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By ERIC R. MILLER, Meteorologist

This dust fall was detected at Madison, Wis., on the afternoon of March 29, 1924, by the author, some of whose studies, in collaboration with Dr. A. N. Winchell, have appeared in this REVIEW¹ and elsewhere.²

So generous have been the responses to our requests for cooperation that we have been provided with more samples of dust for analysis, and more reports showing the distribution of the dust than we have had for any previous dust fall.

Sixteen Weather Bureau stations in Nebraska, Iowa, Minnesota, Illinois, Missouri, Indiana, and Michigan, among 26 to which telegrams were sent from Washington by Supervising Forecaster E. H. Bowie, reported finding dust in the rain or snow. Mr. A. M. Hamrick, at Davenport, Iowa, secured the repetition of the request by radiophone from broadcasting station "WOC" and obtained 30 positive replies and 8 samples of dust from listeners in Iowa, Illinois, Missouri, and Wisconsin. A similar request sent out from "WHA" at Madison was interfered with by static and brought only a few replies. Postal-card inquiries addressed to directors of climatological sections in all States east of the Rocky Mountains brought reports of dust-raising winds in Texas, Oklahoma, Kansas, and Arkansas, of thick haze in Kentucky and Tennessee and of dust falls in the same list of States as that given above. No dust falls were observed east of Michigan and Indiana nor south of Tennessee. The most copious samples were taken in the upper Mississippi Valley.

The mechanism by which the dust was raised, transported, and deposited can be most easily understood by reference to the weather maps for March 28 and 29, 1924, and to the diagrams of storm structure due to Shaw³ and Bjerknes.⁴ The dust was blown up from the ground by the "sirocco" that formed the southern sector of the storm and carried northeastward against and up over the flank of the cold "northeaster" that hugged the ground north of the "steering line." Rain and snow produced by mechanical cooling in the ascent of the warm air washed down the dust, bringing it to earth in the "rain stripe" that characterizes the cold "northeaster" of every cyclone.

At Des Moines, Iowa, Springfield and Peoria, Ill., the dust was washed down in rain. North of a line through

The following test was made, which points directly to this source:

A number of dead leaves taken from the trees in the neighborhood of Cheam were placed in a tin box on the bottom of which a wet cloth was placed, and above the cloth a microscopic slide, the leaves being placed above this. After a couple of days the slide was removed, the leaves having been agitated slightly, and on examination under the microscope it was found to be covered by cells identical in appearance, dimensions and shape with those referred to as having been obtained from the air. (Figs. 9-11, Pl. III.)

The presence of these mold cells in the air in large numbers during the fall of the leaves may have some pathological significance, but what it is the author is unable to suggest at present. As a rule mold cells are nonpathogenic but it appears possible that they may have some effect which has not previously been realized.

Davenport and Chicago the precipitation was in the form of snow. The percentage of dust diminished with distance northward until it became so scanty at Duluth as to be found with difficulty.

It is proposed to procure thorough and exact chemical, mechanical, and microscopical analyses of the dust in the laboratories of the University of Wisconsin. A grant of \$200 has been requested from the research fund of the University of Wisconsin to defray necessary expenses in making analyses.

The most important things that it is proposed to study are (1) data that will be useful in interpreting the loess deposits of the glacial period, (2) the enrichment of the soils of the upper Mississippi Valley by dust blown from the more alkaline soils of the Southwest, and (3) the bacterial fauna accompanying the dust.

Information on the third of these points has already been supplied by Dr. J. G. Dickson of the department of plant pathology of the University of Wisconsin, who has germinated spores of various rusts and fungi from material that he collected on the afternoon of March 29, 1924, while the dust was still falling. He found the spores in the dust to be in a state that will not be reached by local spores until late in May, i. e., nearly two months farther advanced.

Previous analyses of dust falls have indicated that the present rate of deposit of dust from the atmosphere is much slower than must have prevailed in the glacial period. The samples from the present storm will not advance this information greatly for the reason that only those taken at Madison, Wis., and Windsor, Wis., a near-by village, were collected from measured areas of snow. If future dust falls deposit dust at the same rate, it will indicate that storms of the same type as that of March 29, 1924, were much more frequent in the glacial period than at present. This seems to be a reasonable deduction, since according to Bjerknes they tend to follow the "polar front" which is necessarily associated with the margin of the polar cap of snow, because the snow surface and the air above it are much colder than the air over bare ground. In the glacial period when this margin remained in these latitudes instead of retreating far to the northward as at present, it seems probable that "Colorado" storms were more frequent, and that dust was more continuously deposited. For these reasons it also seems probable that the loess was deposited in glacial rather than in interglacial epochs, as some geologists have suggested.

¹ Dust falls of March, 1918. *MO. WEATHER REV.*, 46: 502.

² Same, *American Journal of Science*, 46: 599.

³ Forecasting Weather, Washington, 1911, fig. 96, p. 212.

⁴ Structure of the Atmosphere when Rain Is Falling. *Q. J. Roy. Met. Soc.* 46: 128, and also *MO. WEATHER REV.*, 48: 401, July, 1920.